Androgen receptor gene polymorphisms lean mass and performance in young men

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Accepted 3 July 2009
Published Online First 16 July 2009

ABSTRACT

The exon-1 of the androgen receptor (*AR*) gene contains two repeat length polymorphisms which modify either the amount of *AR* protein inside the cell (GGN_n, polyglycine) or its transcriptional activity (CAG_n, polyglutamine). Shorter *CAG* and/or *GGN* repeats provide stronger androgen signalling and vice versa. To test the hypothesis that *CAG* and *GGN* repeat *AR* polymorphisms affect muscle mass and various variables of muscular strength phenotype traits, the length of *CAG* and *GGN* repeats was determined by PCR and fragment analysis and confirmed by DNA sequencing of selected samples in 282 men (28.6±7.6 years). Individuals were grouped as *CAG short* (CAG_S) if harbouring repeat lengths of ≤21 and *CAG long* (CAG_L) if *CAG* >21. *GGN* was considered short (GGN_S) or long (GGN_L) if *GGN* ≤23 or >23, respectively. No significant differences in lean body mass or fitness were observed between the CAG_S and CAG_L groups, or between GGN_S and GGN_L groups, but a trend for a correlation was found for the *GGN* repeat and lean mass of the extremities (r=−0.11, p=0.06). In summary, the lengths of *CAG* and *GGN* repeat of the *AR* gene do not appear to influence lean mass or fitness in young men.

INTRODUCTION

Muscle mass and strength, as well as aerobic fitness (VO_2max) are related to health and mortality.[1] Muscle mass and strength is determined by environmental factors, principally endocrine, nutritional and mechanical loading, and by the genetic background.[2] Gene polymorphisms, like those encoding for the insulin-like growth factor-1 (*IGF-1*),[3] type I collagen (*COL1A1*),[4] ciliary neurotrophic factor (*CNTF*),[5] interleukin-6 (*IL-6*),[6] the vitamin D receptor (*VDR*),[7] *IGF-2*,[8] resistin (*RETN*)[9] and androgen receptor (*AR*),[10] have an influence on either muscle mass or strength.

The *AR* gene is located to the X chromosome (q11.2–q12), and contains eight exons. The exon 1 contains a polyglutamine tract encoded by *CAG* repeats and a polyglycine tract (*GGN*) encoded by $(GGT)_3GGG(GGT)_2(GGC)_n$. Polymorphic tracts are close to the region encoding the transactivation-1 domain of the *AR* protein.[11] The *CAG* and *GGN* polymorphisms of the *AR* gene are related to incidence of prostatic cancer, breast cancer, plasma hormone levels and other metabolic, cardiovascular and even mental diseases.[12–15]

The polyglutamine repeat has an average length of 22 amino acids (range: 8–35). Short *CAG* repeats are associated with increased *AR* transactivation activity and stronger transcriptional potential.[16] The *CAG* polymorphisms are associated with the fat-free mass phenotype in healthy elders.[10] However, it remains to be established if the *AR* polymorphism influences muscle mass and fitness in young adults.

The polyglycine repeat length of *AR* ranges from 10 to 30.[17] Short *GGN* repeats are associated with increased *AR* protein content in cell cultures that may in turn enhance the response to androgen stimulation.[18] It remains unknown if a short *GGN* repeat number is associated to increased muscle mass or strength in humans.

The aim of this study was to determine if AR polymorphisms are associated to muscle mass and physical fitness in adult men. We tested the hypothesis of whether men with short *CAG* and/or short *GGN* repeats have greater fat-free mass and muscle mass, and, therefore, greater strength and muscle power, than those harbouring long *CAG* and/or long *GGN* repeats. Since studies in cell culture and animal models have shown that androgen–*AR* signalling pathway increases the expression of slow-twitch-specific skeletal muscle proteins leading to a more oxidative phenotype,[19] we also studied whether *AR* polymorphisms have an effect on aerobic power (VO_2max) in humans. This information may be useful to elaborate genetic profiles like those recently proposed by Lucia *et al*[20–22] to explain individual variations in human physical performance.

METHODS

Subjects

Two-hundred and eighty-two Caucasian men participated in the study. They were recruited from physically active university students, sports clubs and local police officers in Gran Canaria (Spain). Recruitment started in February 2003 and extended to June 2007. The health status of each participant was established by a medical history and physical examination. Subjects taking any kind of medications or having any chronic disease or hypertension were excluded. The study was performed in accordance with the Helsinki Declaration of 1975 as regards the conduct of clinical research, being approved by the Ethical Committee of the University of Las Palmas de Gran Canaria. All volunteers provided their written informed consent before participation in the study.

Tests

Tests were carried out over 4 days. The first testing day started with a 20-ml blood sample which was obtained from an antecubital vein in the supine position, between 7:30 and 8:30. Body composition, jumping performance and maximal isometric force was tested on the second day. The last 2 days were used to assess sprint performance and anaerobic capacity, as well as maximal aerobic power (VO_2max).

Body composition

Whole body composition was assessed by dual-energy x-ray absorptiometry (DXA; QDR-1500; Hologic Corp., software version 7.10, Waltham, Massachusetts, USA) as reported in Perez-Gomez *et al*.[23] Upper and lower limb lean mass (kg) was calculated from the regional analysis of the whole body scan,[24 25] which gives a valid and reliable estimate of muscle mass in the extremities.[26]

Vertical jump performance and running sprint tests

The forces generated during vertical jumps were measured with a force platform (Kistler, Winterthur, Switzerland), as reported in Ara *et al*.[27] Two kinds of jumps were performed: squat jump, in which countermovement was not permitted, and countermovement jump, from standing position subjects were asked to perform a countermovement, intending to reach knee bending angles of around 90° just before impulsion.

Subjects performed three maximal indoor 30-m running sprint trials to assess running speed with photocells (General ASDE, Valencia, Spain). Each sprint was separated by at least 5-min rest, and the best performance was recorded.[28]

Anaerobic capacity

An all-out 300-m running test was used to estimate the anaerobic capacity, since the anaerobic metabolic pathways contribute more than 50% to the overall energy expenditure during all-out exercise tests with a duration between 30 and 60 s.[29] The test was performed on a 400-m track; the time was recorded manually with a digital stopwatch.

Aerobic maximal power

The maximal oxygen uptake (VO_2max) was estimated using the maximal multistage 20-m shuttle run.[30] The time during which the subjects were able to run for was recorded to calculate VO_2max.

CAG and GGN repeat polymorphisms

DNA was extracted from blood samples (200 µl) using High Pure PCR Template Preparation Kits (Roche Applied Science). To determine the length of the *CAG* and *GGN* repeats, the corresponding regions located on the exon 1 of the *AR* gene (Genbank accession no. M27423) were amplified using two pairs of primers whose sequences have been previously reported.[13] One primer from each pair was marked with fluorescent dye (FAM or VIC). Amplification was performed in a 25-µl reaction volume, containing 50 ng of genomic DNA, 200 µM of each deoxynucleotide triphosphate, 1× FastStart Taq DNA polymerase Buffer (Roche Applied Science, Mannheim, Germany), 1× GC-rich solution buffer (Roche Applied Science) and 1 U of FastStart Taq DNA polymerase (Roche Applied Science). The concentration of each pair of primers was 1.2 and 1.5 µM for the amplification of the *CAG* and *GGN* repeats, respectively. PCR conditions were 30 cycles of 95°C for 45 s, 56°C for 30 s and 72°C for 30 s for *CAG* amplification; 30 cycles of 95°C for 1 min, 55°C for 2 min and 72°C for 2 min for *GGN* amplification. Each PCR was initiated with a denaturation step at 95°C for 5 min and terminated with an extension step at 72°C for 5 min. The PCR product was diluted 1:100 in distilled water, and 1 µl of the dilution was mixed with 10 µl of formamide and 0.3 µl of GeneScan 500 LIZ Size Standard (Applied Biosystems, Warrington, UK), denatured at 98°C for 5 min and cooled on ice. Fragment separation was performed by automated capillary electrophoresis, using an ABI Prism 3100 Genetic Analyzer (Applied Biosystems), and the length was determined with GeneScan Analysis Software (version 3.7; Applied Biosystems). Internal standards supplied by the manufacturer were used for quality control. We blindly repeated the genotype analysis in 54 of the samples, and the results were completely coincident. The fragments size was confirmed by sequencing 48 DNA samples harbouring different size alleles for both repeats by using the BigDye Terminator Sequencing Kit (Applied Biosystem) at University of Las Palmas Sequencing Facility. Genotyping was performed specifically for research purposes based on the hypothesis that the aforementioned polymorphisms may influence VO_2max, lean mass and muscle strength. The genotype data of the subjects were not previously analysed for other non-research purposes and as such were not presented a posteriori for the present paper. The researchers in charge of genotyping were totally blinded to the subjects' identities, that is, blood samples were tracked

Table 1 Subject's body composition, anthropometrics, physical activity and fitness (mean±SD)

	Mean±SD	n
Age (years)	28.8±7.6	282
Height (cm)	176.8±5.5	282
Body mass (kg)	79.2±10.3	282
Percentage of body fat	19.3±7.3	282
Lean body mass (kg)	59.5±5.6	282
Lean body mass/Ht^2 (kg/m^2)	19.0±1.5	282
Lean mass arms (kg)	6.7±0.9	282
Lean mass legs (kg)	19.8±2.2	282
Lean mass extremities (kg)	26.4±2.9	282
Lean mass arms/Ht^2 (kg/m^2)	2.1±0.3	282
Lean mass legs/Ht^2 (kg/m^2)	6.3±0.6	282
Lean mass extremities/Ht^2 (kg/m^2)	8.4±0.8	282
Sports history (years)	8.0±6.0	282
Jumping tests		
SJJH (m)	0.292±0.054	251
SJWmax (w)	3409±536	192
SJWmax/MML (w/kg)	173±19	192
CMJJH (m)	0.331±0.061	252
CMJWmax (w)	3586±556	194
CMJWmax/MML (w/kg)	180±28	192
Strength		
MVC (kgf)	106±21	237
MVC/MML (kgf/kg)	5.4±1.0	237
Running test		
$T_{30\,m}$ (s)	4.53±0.29	272
$T_{300\,m}$ (s)	50.17±8.65	271
Aerobic power		
VO_2max (ml/kg/ml)	47.3±7.5	267

CMJJH, jumping height in countermovement jumps; CMJWmax, maximal power in countermovement jumps; CMJWmax/MML, maximal power in countermovement jumps per kg of muscle mass in the lower extremities; Ht, height; MVC, maximal isometric force in the squatting position; SJJH, jumping height in squat jumps; SJWmax, maximal power in squat jumps; SJWmax/MML, maximal power in squat jumps per kg of muscle mass in the lower extremities (MML); $T_{30\,m}$ and $T_{300\,m}$, running time in the 30 and 300 m running sprint, respectively.

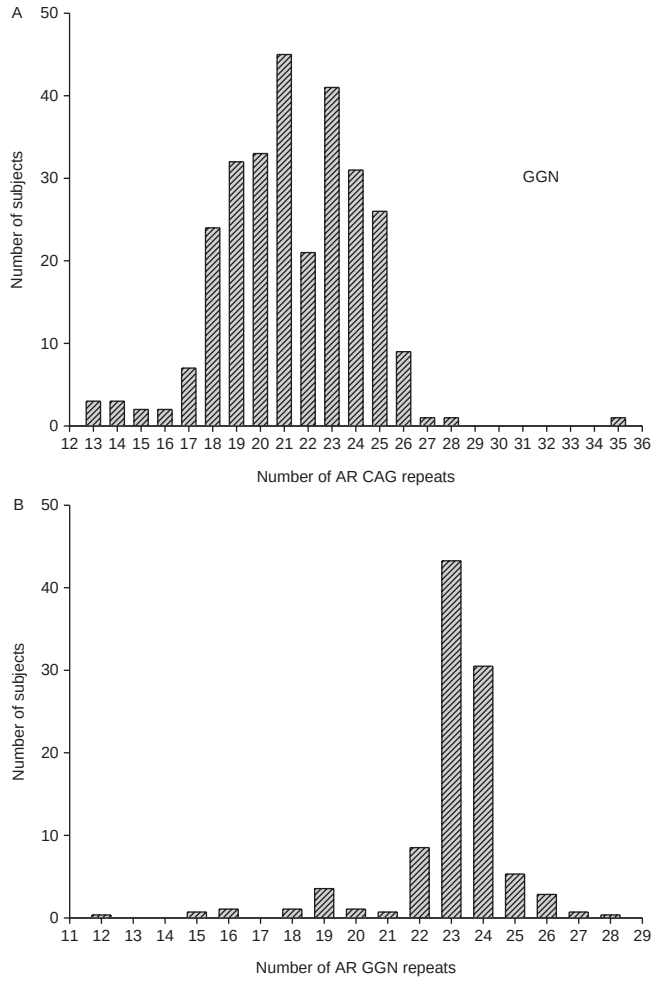

Figure 1 Histogram with the number of subjects with each (A) CAG and (B) GGN repeat number.

solely with code numbers, and personal identities were only made available to the main study researcher who was not involved in actual genotyping.

Statistical analysis

All variables were checked for normal distribution by the Kolmogorov–Smirnov test. When necessary, the analysis was done on logarithmically transformed data. The influence of *CAG* and *GGN* repeat lengths on body composition and fitness was determined taking *CAG* and *GGN* repeat lengths as either continuous variables or as dichotomous variables with allele cut-off thresholds. The relationship between *CAG* and *GGN* as continuous variables with lean body mass and physical fitness variables was examined using linear regression analysis. The median value which resulted in the most balanced grouping was used as cut-off threshold. Thus, individuals were grouped as *CAG* short (CAG_S; n=151) if harbouring repeat lengths ≤21 and *CAG* long (CAG_L; n=131) if harbouring repeat lengths >21. Subjects were ascribed to the *GGN* short (GGN_S; n=170) group if harbouring repeat lengths of ≤23; otherwise, they were included in the *GGN* long (GGN_L; n=112) group. In addition, the subjects were also grouped if having any of the following haplotype combinations: CAG_S+GGN_L (n=64), CAG_L+GGN_S (n=83), CAG_L+GGN_L (n=48) and CAG_S+GGN_S (n=87).

Mean values were compared using analysis of variance with two factors (*CAG* and *GGN* lengths), each with two levels (short and long repeat number). Pairwise comparisons were tested for statistical significance using the Bonferroni post hoc test. Lean mass was corrected for differences in height by dividing muscle mass by height.[2 31]

RESULTS

Subject's body composition, anthropometrics, physical activity and fitness are reported in table 1. The observed allele frequencies for *AR CAG* and *GGN* repeat numbers in the studied subjects are presented in fig. 1. There were 17 different *CAG* alleles (ranging from 13 to 35 repeats) and 14 *GGN* alleles, ranging from 12 to 28 repeats.

CAG repeat polymorphism

Subject's body composition, anthropometrics, physical activity and fitness in the GGN_S and GGN_L groups are reported in table 2. The *CAG* polymorphism was not associated to any studied variable. No significant differences were found either in lean body mass or fitness between the CAG_S and CAG_L groups (table 2). There was no relationship between the length of the *CAG* repeat polymorphism and lean mass or physical fitness variables.

GGN repeat polymorphism

Subject's body composition, anthropometrics, physical activity and fitness in the GGN_S and GGN_L groups are reported in table 3. A trend for a significant inverse association between the logarithm of the length of the *GGN* polymorphism and the muscle mass of the extremities (MME) expressed as kg/height^2 was observed (MME=11.6–2.3×Lg *GGN*, R=0.11, p=0.06). The length of the *GGN* repeat polymorphism did not correlate with any of the physical fitness variables assessed.

Interaction between CAG and GGN repeat polymorphism

The body composition, anthropometrics, physical activity and fitness of men grouped as CAG_L+GGN_L, CAG_S+GGN_S, CAG_S+GGN_L and CAG_L+GGN_S are reported in table 4. Although men having the combination CAG_S and GGN_S jumped 9.0% higher than those having the combination CAG_L and GGN_L (table 4), this effect was not significant after accounting for multiple comparisons (p=0.13). Differences between allele combinations in other physical fitness and lean mass variables were not significant, even without accounting for multiple comparisons.

DISCUSSION

This study shows that in physically active young men, AR polyglycine and polyglutamine repeat polymorphisms have no influence on lean mass or fitness when studied alone. Although the subjects with the combination CAG_S and GGN_S jumped higher than those with the combination of CAG_L and GGN_L, this effect disappeared after accounting for multiple comparisons. However, we cannot rule out a potential type II error, implying that this effect needs to be verified in future studies.

In agreement with previous studies, we did not observe any association between height and length of the *CAG* repeat polymorphism in men.[10] Although the subjects having a *CAG* repeat number >22 had a 1.1% greater height^2-adjusted lean body mass than the group with shorter alleles, this difference did not reach statistical significance. This is in contradiction to results from Walsh *et al*[10] that reported a 2% greater lean body mass in the subjects with a *CAG* repeat number ≥22, in a group of 294 men with a mean age of 73 years. The difference between both studies is likely due to the fact that our subjects

Table 2 Body composition, anthropometrics, physical activity and fitness in men with CAG_S and CAG_L androgen receptor polymorphisms (mean±SD)

	CAG_S	n	CAG_L	n
Age	28.3±7.6	151	29.5±7.6	131
Height (cm)	176.5±5.3	151	177.1±5.8	131
Body mass (kg)	77.5±9.7	151	78.8±10.9	131
Percentage of body fat (%)	19.3±6.7	151	19.3±8.0	131
Lean body mass (kg)	59.1±5.8	151	60.0±5.4	131
Lean mass arms (kg)	6.6±1.0	151	6.8±0.9	131
Lean mass legs (kg)	19.7±2.3	151	19.8±2.0	131
Lean mass extremities (kg)	26.3±3.1	151	26.6±2.7	131
Lean mass arms/Ht^2 (kg/m^2)	2.1±0.3	151	2.2±0.3	131
Lean mass legs/Ht^2 (kg/m^2)	6.3±0.6	151	6.3±0.6	131
Lean mass extremties/Ht^2 (kg/m^2)	8.4±0.9	151	8.5±0.8	131
Sports history (years)	7.9±6.3	145	8.1±5.3	128
Jumping tests				
SJJH (m)	0.30±0.05	133	0.29±0.05	118
SJWmax (w)	3387±544	94	3429±530	98
SJWmax/MML (w/kg)	173.5±18.7	94	172.1±19.2	98
CMJJH (m)	0.34±0.06	134	0.32±0.06	118
CMJWmax (w)	3571±595	96	3601±519	98
CMJWmax/MML (w/kg)	180.9±31.1	94	178.6±25.1	98
Strength				
MVC (kg)	105.8±22.0	126	107.0±20.4	111
MVC/MML (kg/kg)	5.4±1.0	126	5.4±1.0	111
Running tests				
$T_{30\,m}$ (s)	4.51±0.25	147	4.56±0.33	125
$T_{300\,m}$ (s)	49.7±7.1	148	50.7±10.2	123
Maximal aerobic power				
VO_2max (ml/kg/min)	47.0±7.9	142	47.7±7.1	124

CMJJH, jumping height in countermovement jumps; CMJWmax, maximal power in countermovement jumps; CMJWmax/MML, maximal power in countermovement jumps per kg of muscle mass in the lower extremities; Ht, height; MVC, maximal isometric force in the squatting position; SJJH, jumping height in squat jumps; SJWmax, maximal power in squat jumps; SJWmax/MML, maximal power in squat jumps per kg of muscle mass in the lower extremities (MML); T_{30m} and $T_{300\,m}$, running time in the 30 and 300 m running sprint, respectively.

Table 3 Body composition, anthropometrics, physical activity and fitness in men and women with GGN_S and GGN_L androgen receptor polymorphisms (mean±SD)

	GGN_S	n	GGN_L	n
Age	28.7±7.1	170	29.1±8.4	112
Height (cm)	176.6±5.5	170	177.1±5.6	112
Body mass (kg)	77.5±9.8	170	79.1±10.9	112
Percentage of body fat (%)	19.0±6.9	170	19.7±7.9	112
Lean body mass (kg)	59.4±5.9	170	59.8±5.2	112
Lean mass arms (kg)	6.6±1.0	170	6.7±0.9	112
Lean mass legs (kg)	19.7±2.3	170	19.9±2.1	112
Lean mass extremities (kg)	26.3±3.0	170	26.6±2.8	112
Lean mass arms/Ht^2 (kg/m^2)	2.1±0.3	170	2.1±0.3	112
Lean mass legs/Ht^2 (kg/m^2)	6.3±0.6	170	6.3±0.6	112
Lean mass extremties/Ht^2 (kg/m^2)	8.4±0.8	170	8.5±0.8	112
Sports history (years)	7.8±5.9	165	8.3±5.8	108
Jumping tests				
SJJH (m)	0.29±0.05	150	0.29±0.06	101
SJWmax (w)	3394±519	118	3432±566	74
SJWmax/MML (w/kg)	172.1±18.8	118	174.0±19.2	74
CMJJH (m)	0.34±0.06	151	0.32±0.06	101
CMJWmax (w)	3594±549	120	3574±571	74
CMJWmax/MML (w/kg)	180.1±26.9	118	179.0±30.2	74
Strength				
MVC (kg)	107.6±22.0	141	104.6±20.1	96
MVC/MML (kg/kg)	5.5±1.0	141	5.3±1.0	96
Running tests				
$T_{30\,m}$ (s)	4.53±0.27	162	4.54±0.32	110
$T_{300\,m}$ (s)	49.7±7.3	161	50.9±10.3	110
Maximal aerobic power				
VO_2max (ml/kg/min)	47.6±7.3	161	46.9±7.8	105

CMJJH, jumping height in countermovement jumps; CMJWmax, maximal power in countermovement jumps; CMJWmax/MML, maximal power in countermovement jumps per kg of muscle mass in the lower extremities; Ht, height; MVC, maximal isometric force in the squatting position; SJJH, jumping height in squat jumps; SJWmax, maximal power in squat jumps; SJWmax/MML, maximal power in squat jumps per kg of muscle mass in the lower extremities (MML); $T_{30\,m}$ and $T_{300\,m}$ running time in the 30 and 300 m running sprint, respectively.

were much younger (29 years old) and had more appendicular muscle mass but lower height^2-adjusted whole body lean mass than the subjects studied by Walsh *et al*, suggesting that with ageing men may increase trunk lean mass, due to changes in other components of the trunk lean mass apart from the muscle tissue as demonstrated by using potassium whole body counting.[32] No significant differences in lean body mass, height or fitness were observed in men between the CAG_S and CAG_L groups. Like Walsh *et al*,[10] we did not observe significant differences in appendicular muscle mass in men related to *CAG* repeats.

In the present investigation, we have also examined the influence of the *GGN* repeat *AR* polymorphism on muscle mass and physical fitness in healthy men. In agreement, with our hypothesis, there was a trend for an inverse relationship between the length of the *GGN* polymorphism and lean mass.

The possibility for an interaction between the *CAG* and *GGN* repeat polymorphism has not been previously studied. We have observed that the men having the microsatellite combination CAG_S+GGN_S could jump higher than those harbouring the combination CAG_L+GGN_L. The CAG_S+GGN_S microsatellite combination has been associated to stronger androgen signalling[11 14]; however, our results do not give clear support to the hypothesis that this combination may have a favourable influence in power-generating capacity of the skeletal muscles. Jumping performance is determined by body composition[33] and factors that determine the speed of muscle activation and rate of force development, among which is critical the percentage of type II fibres.[34] Performance in the 300-m running test depends not only in great part on the muscle mass[35] but also on other factors which determine the contractile and metabolic properties of the muscles, such as a high percentage of fast-twitch (or type II) fibres and a high anaerobic capacity.[29 36] In theory, the combination of CAG_S+GGN_S may confer a functional advantage for tasks requiring muscle power, but additional studies are required to clarify this point.

It remains to be elucidated if CAG_S and/or GGN_S haplotypes are associated to an increased proportion of type II fibres and/or enhanced anaerobic capacity. Animal studies indicate that increased androgen signalling may stimulate the expression of slow-twitch-specific skeletal muscle proteins while inhibiting fast-twitch-specific skeletal muscle proteins.[19] However, there are no sex differences in muscle fibre types in humans,[37] and 20 weeks treatment with testosterone enanthate did not change muscle fibres in men.[38]

Competing interests None.

Acknowledgements The authors thank José Navarro de Tuero for his excellent technical assistance.

Funding The study was supported by Ministerio de Educación y Ciencia (DEP2006-56076-C06-04/ACTI) and FEDER, Consejería de Educación, Cultura y Deportes del Gobierno de Canarias (2006/179 0001 and FEDER), Proyecto Interreg IIIB BIOPOLIS, Fundación del Instituto Canario de Investigación del Cáncer (FICIC), Cabildo de Gran Canaria, Cabildo de Tenerife and La Caja de Canarias, and Proyecto Estructurante "Integración de los grupos de investigación en Ciencias de la Salud entorno al estudio de la obesidad y el síndrome metabólico con un enfoque molecular, celular, fisiopatológico, epidemiológico y psicosocial", ULPGC, Gobierno de Canarias.

Ethics approval This study was conducted with the approval of the University of Las Palmas de Gran Canaria.

Table 4 Body composition, anthropometrics, physical activity and fitness in men harbouring the microsatellite combinations CAG_L+GGN_L, CAG_S+GGN_S, CAG_S+GGN_L and CAG_L+GGN_S (mean±SD)

	CAG_L+GGN_L	n	CAG_S+GGN_S	n	CAG_S+GGN_L	n	CAG_L+GGN_S	n
Age	29.9±8.1	48	28.1±6.9	87	28.5±8.5	64	29.2±7.3	83
Height (cm)	176.8±6.0	48	176.0±5.2	87	177.3±5.4	64	177.3±5.8	83
Body mass (kg)	80.0±12.8	48	76.9±9.9	87	78.3±9.4	64	78.2±9.7	83
Percentage of body fat (%)	20.6±8.6	48	19.5±6.2	87	19.1±7.3	64	18.5±7.6	83
Lean body mass (kg)	59.6±5.3	48	58.5±6.2	87	59.9±5.2	64	60.3±5.5	83
Lean mass arms (kg)	6.7±0.8	48	6.5±1.0	87	6.7±0.9	64	6.8±0.9	83
Lean mass legs (kg)	19.6±2.0	48	19.5±2.4	87	20.1±2.2	64	19.9±2.1	83
Lean mass extremities (kg)	26.3±2.7	48	25.9±3.3	87	26.8±2.9	64	26.7±2.7	83
Lean mass arms/Ht^2 (kg/m^2)	2.1±0.3	48	2.1±0.3	87	2.1±0.3	64	2.2±0.3	83
Lean mass legs/Ht^2 (kg/m^2)	6.3±0.6	48	6.3±0.7	87	6.4±0.6	64	6.3±0.6	83
Lean mass extremties/Ht^2 (kg/m^2)	8.4±0.8	48	8.4±0.9	87	8.5±0.8	64	8.5±0.8	83
Sports history	9.2±5.5	47	8.1±6.6	84	7.6±6.0	61	7.5±5.2	81
Jumping tests								
SJJH (m)	0.28±0.05	44	0.30±0.05	76	0.30±0.06	57	0.29±0.05	74
SJWmax (w)	3438±577	39	3365±537	59	3425±561	35	3423±502	59
SJWmax/MML (w/kg)	175.4±20.3	39	174.1±19.2	59	172.6±18.1	35	170.0±18.3	59
CMJJH (m)	0.31±0.06	44	0.34±0.07	77	0.33±0.06	57	0.33±0.05	74
CMJWmax (w)	3560±577	39	3560±611	61	3591±573	35	3628±479	59
CMJWmax/MML (w/kg)	181.6±19.5	39	183.7±25.3	59	176.1±38.9	35	176.5±28.2	59
Strength								
MVC (kg)	103.9±20.9	44	106.3±23.7	74	105.3±19.5	52	109.1±20.0	67
MVC/MML (kg/kg)	5.3±1.1	44	5.5±1.1	74	5.2±0.9	52	5.5±0.9	67
Running tests								
$T_{30\,m}$ (s)	4.56±0.37	47	4.50±0.23	84	4.52±0.28	63	4.56±0.31	78
$T_{300\,m}$ (s)	51.9±12.5	47	49.4±6.1	85	50.2±8.3	63	50.0±8.5	76
Maximal aerobic power								
VO_2max (ml/kg/min)	46.7±8.3	44	46.9±8.2	81	47.1±7.6	61	48.3±6.3	80

All p>0.10 after accounting for multiple comparisons (Bonferroni post hoc test).
CMJJH, jumping height in countermovement jumps; CMJWmax, maximal power in countermovement jumps; CMJWmax/MML, maximal power in countermovement jumps per kg of muscle mass in the lower extremities; Ht, height; MVC, maximal isometric force in the squatting position; SJJH, jumping height in squat jumps; SJWmax, maximal power in squat jumps; SJWmax/MML, maximal power in squat jumps per kg of muscle mass in the lower extremities (MML); $T_{30\,m}$ and $T_{300\,m}$ running time in the 30 and 300 m running sprint, respectively.

Provenance and peer review Not commissioned; externally peer reviewed.

Patient consent Obtained.

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Take home message

The length of *CAG* and *GGN* repeat of the *AR* gene do not appear to influence lean mass or fitness in young men. Additional studies are required to test if men harbouring the combination CAG_S and GGN_S have more jumping capacity.

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Br J Sports Med 2011 45: 95-100 originally published online July 16, 2009
doi: 10.1136/bjsm.2009.060285